My NASA Data - Lesson Plans

Using My NASA Data to Find Evidence of Volcanic Activity

Purpose

Students will use NASA satellite data of aerosol optical depth and sulfur dioxide as a tool to find evidence of volcanic activity at Kilauea, HI.

Learning Objectives

- Analyze data to find evidence of volcanic activity.
- Analyze more than one data source for evidence of activity.
- Make a claim based on evidence of when volcanic activity slowed or stopped.
- Share your findings with others.

Why Does NASA Study This Phenomenon?

NASA Getting the Big Picture

NASA uses satellites for many different purposes. Watch this video for general information.

Source

About the NASA Disasters Program

The Disasters Applications area promotes the use of Earth observations to improve prediction of, preparation for, response to, and recovery from natural and technological disasters. Disaster applications and applied research on natural hazards support emergency preparedness leaders in developing mitigation approaches, such as early warning systems, and providing information and maps to disaster response and recovery teams.

Source

In order to accomplish these goals, satellite data are used. To study volcanoes, multiple instruments on satellites are used. Those highlighted in this lesson are the OMI and MISR instruments.

About OMI

The Ozone Monitoring Instrument (OMI) instrument can distinguish between aerosol types, such as smoke, dust, and sulfates, and measures cloud pressure and coverage, which provides data to derive tropospheric ozone.

OMI continues the TOMS record for total ozone and other atmospheric parameters related to ozone chemistry and climate. OMI measurements are highly synergistic with the other instruments on the Aura platform.

The OMI instrument employs hyperspectral imaging in a push-broom mode to observe solar backscatter radiation in the visible and ultraviolet. The hyperspectral capabilities improve the accuracy and precision of the total ozone amounts and also allow for accurate radiometric and wavelength self calibration over the long term.

The instrument is a contribution of the Netherlands's Agency for Aerospace Programs (NIVR) in collaboration with the Finnish Meteorological Institute (FMI) to the Aura mission.

Source

MISR

This instrument is aboard the NASA Terra Satellite launched on December 18, 1999.

Most satellite instruments look only straight down, or toward the edge of the planet. To fully understand Earth's climate, and to determine how it may be changing, we need to know the amount of sunlight that is scattered in different directions under natural conditions. MISR is a new type of instrument designed to address this need — it views the Earth with cameras pointed at nine different angles. One camera points toward nadir, and the others provide forward and aftward view angles, at the Earth's surface, of 26.1°, 45.6°, 60.0°, and 70.5°. As the instrument flies overhead, each region of the Earth's surface is successively imaged by all nine cameras in each of four wavelengths (blue, green, red, and near-infrared).

In addition to improving our understanding of the fate of sunlight in the Earth's environment, MISR data can distinguish different types of clouds, aerosol particles, and surfaces. Specifically, MISR will monitor the monthly, seasonal, and long-term trends in:

- the amount and type of atmospheric aerosol particles, including those formed by natural sources and by human activities;
- the amount, types, and heights of clouds; and
- the distribution of land surface cover, including vegetation canopy structure

Source

Essential Questions

How can satellite data be used to detect volcanic activity?

Materials Required

- Data Literacy Map Cubes
- Data Literacy Graph Cubes
- Monthly Aerosol Images for Students
- Monthly SO_2 Images for Students
- Ten Year Aerosol Graph for Students
- Ten Year SO_2 Graph for Students

Technology Requirements

- Internet Required

Teacher Background Information

NASA Monitoring of Sulfur Dioxide from Space

Sulfur dioxide is a colorless gas with a pungent odor that irritates skin and the tissues and mucous membranes of the eyes, nose, and throat. SO_2 emissions can cause acid rain and air pollution downwind of a volcano—at K?lauea volcano in Hawaii, high concentrations of sulfur dioxide produce volcanic smog (VOG) causing persistent health problems for downwind populations. During very large eruptions, SO_2 can be injected to altitudes of greater than 10km into the stratosphere. Here, $SO_2$is converted to sulfate aerosols which reflect sunlight and therefore have a cooling effect on the Earth's climate. They also have a role in ozone depletion, as many of the reactions that destroy ozone occur on the surface of such aerosols.


Volcanic Smog (vog) is produced from sulfur dioxide gas and is a hazard in Hawaii. Scientists monitor sulfur dioxide emission rates at Kilauea volcano. This image show gasses from the Halema'uma'u crater, located in the summit caldera of Kilauea.

Source 1, Source 2

Aerosol Remote Sensing and Modeling

The Climate and Radiation Lab (CRL) has a very active group studying the climate and health impacts of airborne particles ("*aerosols*"). Aerosol particles reflect sunlight, which tends to cool surfaces locally. Some also absorb sunlight, warming and stabilizing the ambient atmosphere while still cooling the surface below, sometimes suppressing cloud formation, and even affecting large-scale atmospheric circulation. In addition, aerosols are essential participants in the formation of cloud droplets and ice crystals, functioning as the collectors of water vapor molecules during the initial stages of cloud development. Particle abundance and properties affect the brightness, thickness, and possibly lifetimes of clouds and ultimately, precipitation and the terrestrial water cycle. And in significant near-surface concentrations they are pollutants, reducing visibility and raising health risks for those exposed.

Airborne particles originate from a great variety of sources, such as wildfires, volcanoes, exposed soils and desert sands, breaking waves, natural biological activity, agricultural burning, cement production, and wood, dung, and fossil fuel combustion. The particles having the largest direct environmental impact are sub-visible, ranging in size from about a hundredth to a few tenths the diameter of a human hair (about 0.1 to 10 microns). They typically remain in the atmosphere from several days to a week or more, and some travel great distances before returning to the Earth's surface via gravitational settling or washout by precipitation. As such, they can affect regions thousands of kilometers from their sources: Dust from the Sahara Desert, transported across the

Atlantic Ocean, supplies iron to the underlying ocean surface waters, occasionally limits visibility in Florida and the Caribbean, and possibly fertilizes the Amazon basin. Pollution and dust from East Asia sometimes reaches North America, and smoke from summertime fires in Siberia, northern Canada, and Alaska darken snow surfaces in the Arctic.

The global scope of aerosol environmental influences makes satellite remote sensing a key tool for the study of these particles. Desert dust storms, wildfire smoke and volcanic ash plumes, and urban pollution palls on hot, cloud-free summer days are among the most dramatic manifestations of aerosol particles visible in satellite imagery.

Procedure

Begin Lesson

1. Ask students what they know about the effects of volcanoes? Discuss this for a few minutes with students. If they bring up volcanic emissions, shift the discussion to aerosols and sulfur dioxide and provide background information. If they do not bring up volcanic emissions, tell the students that among other volcanic hazards, emissions are also a serious hazard. (The word "emissions" describes gases and particles which enter into the air or emitted by different sources.)
2. Show the NASA video: *Fire, Ice, and Safer Skies: NASA Satellites Track Volcanic Clouds* which describes hazards of volcanic emissions. Have students identify why the emissions are a problem and what NASA is tracking to try to predict emissions. (They can impact aviation and ash can melt into glass in plane engines. NASA is tracking sulfur dioxide emissions to help make emission path predictions to give warnings for aviation.)

3. Review the student answers. Clarify that the sulfur dioxide is used as a proxy for the ash clouds. That means it is something that is often found with the ash. If scientists can measure the sulfur dioxide, they can determine where the ash is likely to be as well. The sulfur dioxide is a gas, the ash is small solid particles called particulates or aerosols.
4. Next, show students a video about aerosols.

5. Discuss the following questions with the students.
    1. Identify different sources of aerosols. **(dust, salt from ocean spray, volcanoes, smoke from fires, smokestacks, tailpipes)**
    2. What are the effects of aerosols. **(Can cool by reflecting sunlight, collect water vapor to build a cloud, trap sunlight and heat air to prevent clouds from forming, host chemical reactions which damage ozone layer, cause health problems such as lung and heart disease, be part of haze)**
    3. How does NASA study them? **(satellites, instruments on International Space Station, specialized aircraft and ground instruments)**
    4. Why does NASA study them? **(understand environment and how climate is changing)**
6. Ask the following question. If there are so many different sources of aerosols, how can we know that aerosols we are seeing in data are from a volcano? **(Accept reasonable ideas at this point.)**

Activity Summary

1. Students will work in groups to look at data obtained in the months around a major eruption of Kilauea in HI.
    - Show students the animation of sulfur dioxide from 2013 - 2018. Note that it shows the monthly sulfur dioxide for each month from January 2013 through December 2018 and then starts over with January 2013.

2. Have them answer the following questions.
    - Was there any noticeable change?
    - What might have caused this?
        - Tell students that they need to look for supporting evidence and group them.
    - Distribute the Monthly SO_2 Images for Students to half the groups and the Monthly Aerosols for Students to the other half of the groups.
    - Have students sequence them in order and note the changes over time.
    - Have students select the image from June 2018 and use the My NASA Data Literacy Map cube with the image to answer questions on a separate sheet of paper which will be used to share with their peers.
3. Students will then graph a year of monthly data points for one variable. Have the SO_2 groups graph SO_2 and the aerosols groups graph aerosols.
    - Give the data tables to the appropriate students
    - Have students create their graphs. Make sure they determine the scales for their axes before plotting points. Notice that these are decimal numbers.
4. Have students discuss the graphs with their group.
    - What was the trend over the course of the year?
    - Was there any noticeable change?
    - What might have caused this?
5. Compare the graphs with the images.
    - Does this graph agree with the images for the same variable?
    - What evidence is there that there was strong volcanic activity?
6. Make new groups that have students who analyzed SO_2 and aerosols.
    - Have students explain to their group the variables they analyzed.

Make a Claim and Support With Evidence

1. Have students make a claim about the significance of the volcanic activity at Kilauea in 2018.
2. Distribute the Ten Year Aerosol Graph for Students and the Ten Year SO_2 Graph for Students.
3. Have students use the My NASA Data Literacy Graph Cube to answer questions about the graphs.

Close the Lesson

1. Students should share out their claims and evidence with the class. Initiate discussion in cases where their observations are different. Engage students in the process of going deeper in their observations during these times. Initiate discussion about the importance of sharing science among a bigger community as this is a key part of the practice of science.
2. Have students write an exit ticket consisting of a claim using evidence and explaining their reasoning.